



USTER® ZWEIGLE TWIST TESTER 5

Application Report

Measurement and significance of yarn twist

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1 Introduction

Yarn twist belongs to the basic quality characteristics of ring-spun yarns. Yarn twist also determines the productivity of a mill because more twist means less productivity. Therefore, it is of utmost interest to find the optimum twist.

There is also a relationship between twist and diameter, density, hairiness, strength and elongation.

Yarn twist should be within narrow limits. Otherwise, the specialists may be faced with various problems such as yarns of different dye uptake, visible stripes in the fabric, reduction of strength and elongation, etc. Particularly dangerous are slow spindles due to defective or contaminated spindle drives on the ring spinning machine.

A reduction of the yarn twist increases the yarn diameter and decreases the density.

The following recommendation has to be followed in order to avoid problems in subsequent processes:

- The variation of yarn twist CV_t should not exceed 3,5% to avoid quality problems which can be recognized by the human eye.

If the variation is higher than this figure, there is a danger that the fault can be seen in the final fabric, particularly after dyeing.

This paper deals with the USTER® *ZWEIGLE TWIST TESTER 5*.

2 Basics of yarn twist

2.1 Calculation of the yarn twist

The following survey shows the calculation rules for twist factors used in the textile industry:

English twist factor: $\alpha_e = \text{turns per inch} / \sqrt{N_{ec}}$

Metric twist factor: $\alpha_m = \text{turns per meter} / \sqrt{N_m}$

Twist factor based on tex: $\alpha_{tex} = \text{turns per meter} \cdot \sqrt{tex}$

The twist per meter of a yarn is dependent on the yarn count. A fine yarn requires more twist than a coarse yarn for the same application. Therefore, the English twist factor takes this into account, e.g. a statement such as: "The twist factor of combed cotton yarn should not exceed the value of 3,7" is valid for the entire count range.

The twist factor is also named twist multiplier in some countries.

Example

A combed cotton yarn Nec 50, has a twist of 1020 per meter. What is the English twist factor?

Turns per inch = $0,0254 \cdot 1020 = 25,91$ [tpi]

$$\text{English twist factor } \alpha_e = \frac{\text{turns per inch}}{\sqrt{\text{Nec}}} = \frac{25,91}{\sqrt{50}} = \frac{25,91}{7,07} = 3,66$$

This is the twist of a hosiery yarn.

2.2 Yarn twist versus yarn count

There is a relationship between the yarn twist and the yarn count as shown in Fig. 1 (cotton yarns).

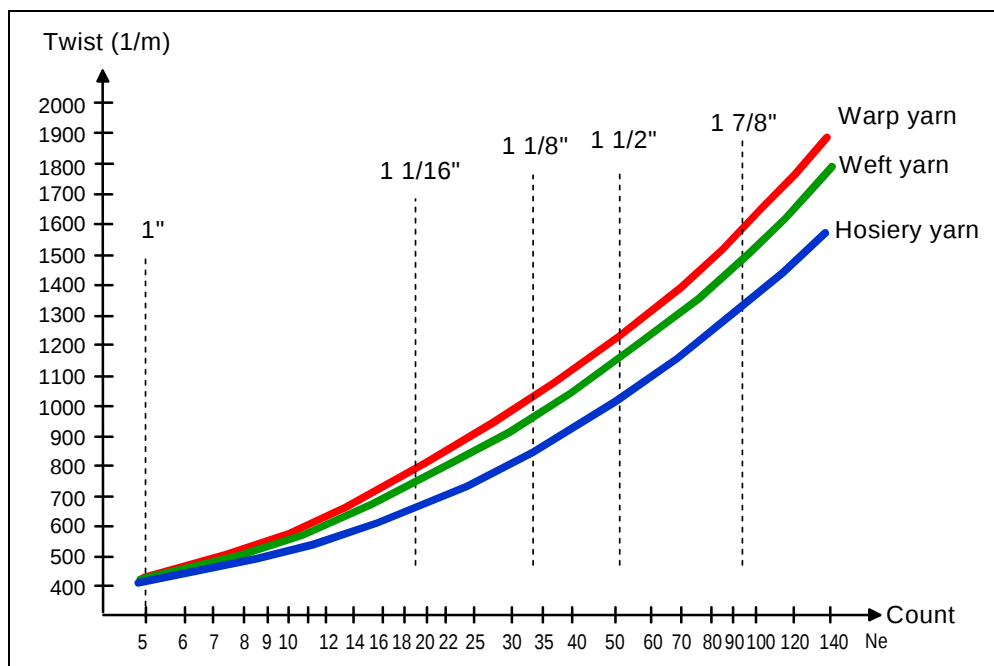


Fig. 1
Relationship between yarn twist and yarn count for ring-spun yarn

Fine yarns require long staple fibers and high twist. Coarse yarns can be produced with short fibers and low twist.

The warp yarns are the yarns with the highest twist.

The twist of weft yarns is approximately 4 – 5 % below the twist of warp yarns.

The twist of hosiery yarns is approximately 12 – 15 % below the twist of warp yarns.

2.3 Yarn twist for a specific end use

Table 1 shows experience values for ring spun yarns. The table is valid for short staple yarns and deals with twist factors for yarns of various applications.

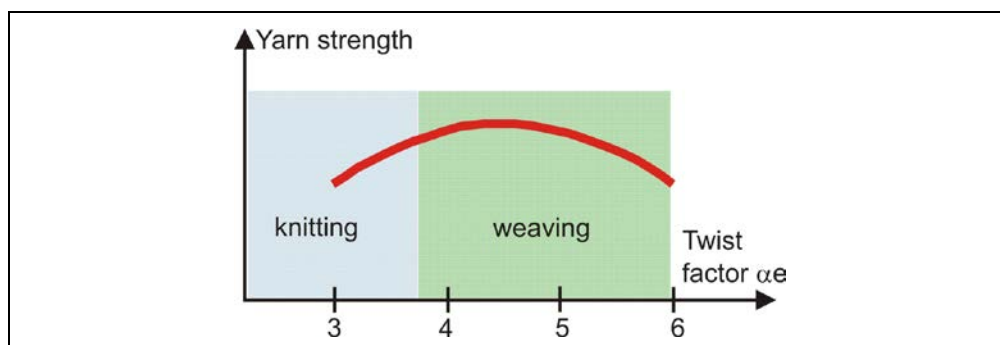
Twist factor		Twist per m Nec 30	Application range	Characteristics
α_e	α_m			
2,5 – 3,9	76 – 118	537 – 824	knitting yarns	soft twist
3 – 4,3	90 – 130	636 – 919	weft yarns	normal twist
3,7 – 4,5	111 – 135	785 – 954	warp yarns, soft	hard twist
4,3 – 4,6	130 – 140	919 – 990	warp yarn, normal	hard twist
4,6 – 5,4	140 – 165	990 – 1167	warp yarn, hard	hard twist
6,3 – 8,9	190 – 270	1343 – 1909	crepe yarns	special twist

Table 1 Twist for various subsequent process

The twist factors are valid for the entire count range. The twist range per meter in Table 1 is only valid for a count of Nec 30 (20 tex).

2.4 Yarn twist limits for knitting yarns

The twist factor for combed cotton yarns for knitted fabrics should not exceed 3.7, whereas in case of carded yarns, a twist factor up to 3.9 is tolerated for yarns for knitted fabrics (Fig. 2).



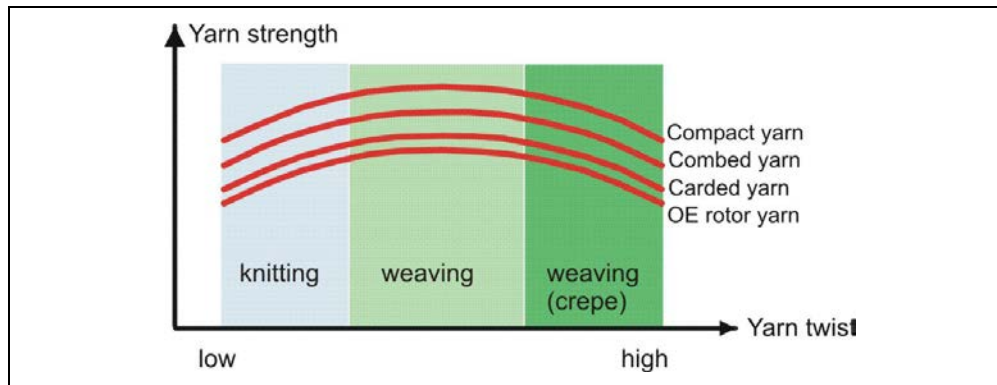
*Fig. 2
Recommendation for yarn
twist limits, combed yarns*

In case of knitting yarns a part of the yarn strength has to be sacrificed for a better and softer handle.

Yarns with low twist are used for knitted fabrics, yarns with high twist are used for crepe yarns. Yarns with average twist are used for regular woven fabrics (Fig. 3).

2.5 Yarn strength versus yarn twist

If the yarn twist increases, the yarn strength increases as well. A warp yarn of medium count Nec 30 reaches the peak value at about 1000 turns per meter. The yarn strength decreases again at higher twist.



*Fig. 3
Relationship between yarn
strength and yarn twist*

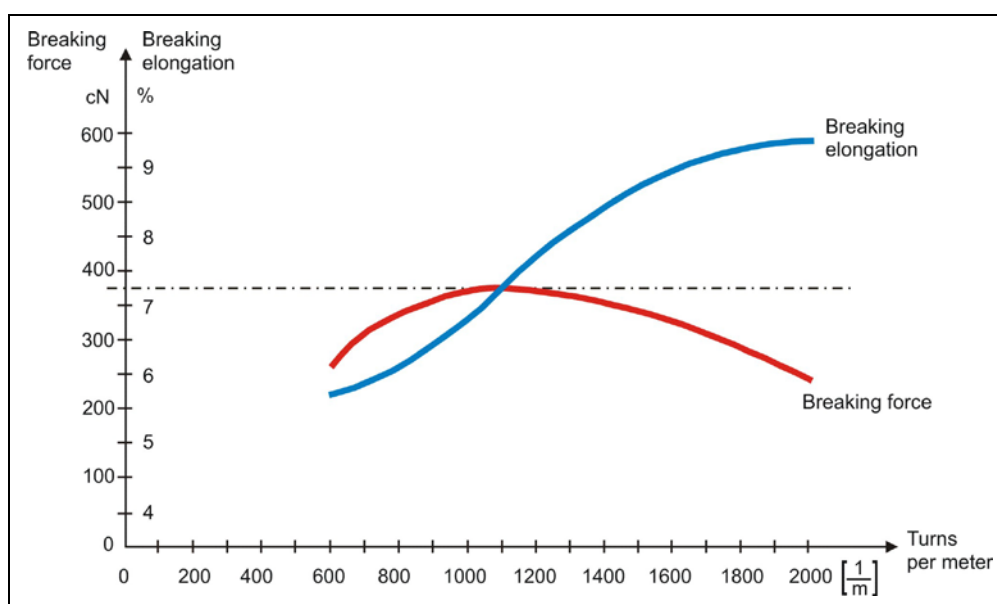
Most of the fibers in the cross-section of compact yarns contribute to the yarn strength.

The protruding fibers of a conventional combed ring-spun yarns do not contribute to the yarn strength.

The short fibers of carded yarns cause a reduction of the yarn strength.

The wrapped fibers of OE rotor yarns do not contribute to the yarn strength.

Fig. 4 demonstrates how strong the twist can influence the breaking force and the elongation of the yarn (combed cotton yarn, 25 tex, Nec 24).

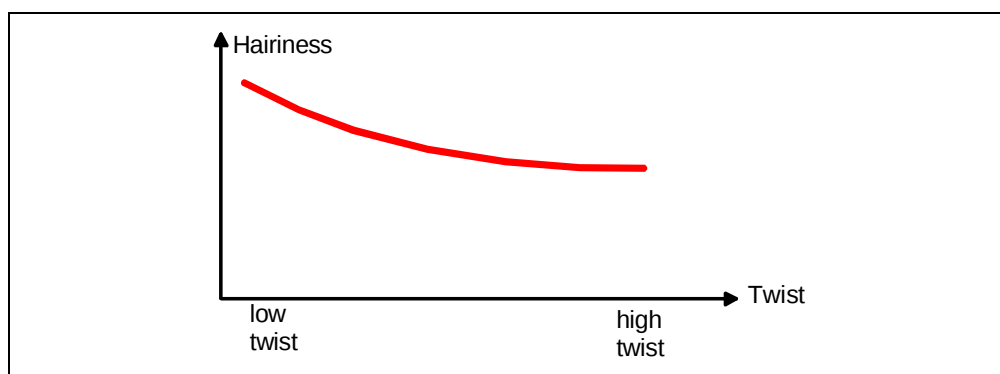


*Fig. 4
Relationship between yarn
braking force / breaking
elongation and twist for a
particular example*

Fig. 4 shows that the highest force is available at a twist level of 1100 per meter for this type of yarn. The yarn force decreases with lower and higher twist. The elongation increases from 600 to 2000 turns per meter. The elongation is 7.25% at the highest yarn force and reaches a value of 9.5% at 2000 turns per meter. These values are only valid for this type of yarn.

2.6 Yarn hairiness versus yarn twist

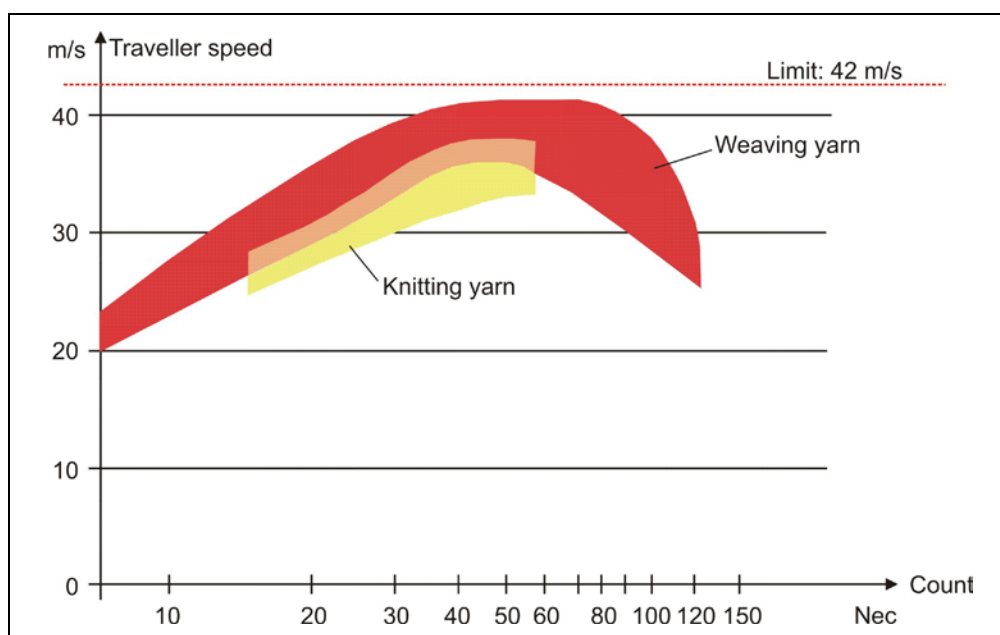
The reduction of twist increases the hairiness because the number of protruding fibers increases. However, there are some limitations concerning the twist multiplier. This value should not exceed 3,7 for combed yarns.



*Fig. 5
Relationship between yarn
hairiness and yarn twist*

2.7 Yarn twist and productivity

Fig. 6 shows the relationship between ring traveller speed and count.



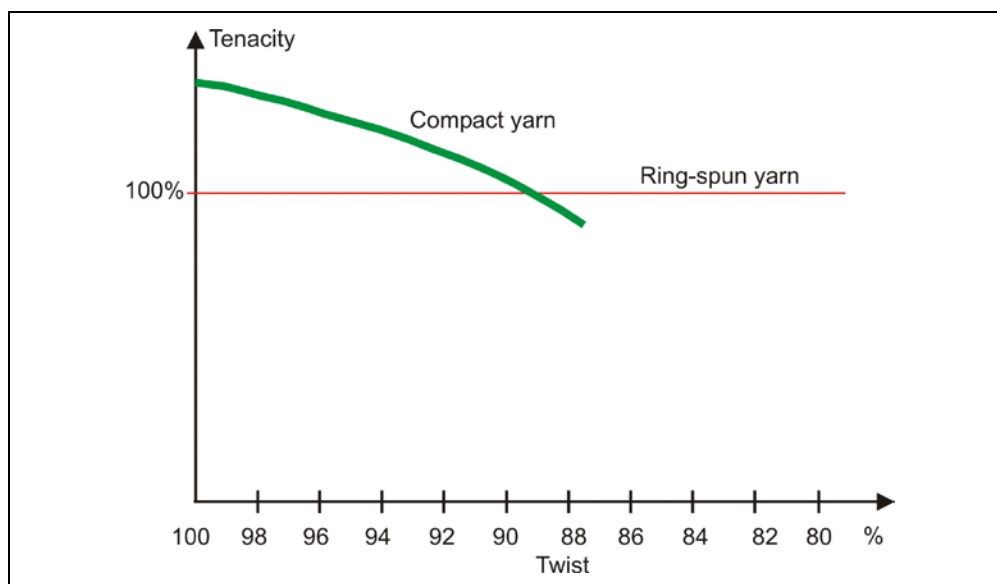
*Fig. 6
Relationship between ring
traveller speed and yarn
count
(Source: Bräcker)*

The yarn twist determines the productivity in a spinning mill to a large extent. However, as already described, the degrees of freedom are limited. In order to reach a yarn strength required for a warp yarn, the turns per meter have to exceed 1000 per meter for an average count. Another limiting element is the maximum speed of ring travellers which is about 42 (m/s). The alternatives are smaller rings for the ring travellers and, therefore, smaller bobbins. This results in more splices per kilometer.

2.8 Yarn twist and compact yarn

A compact yarn has very little protruding fibers because most of the fibers are embedded in the yarn body. Therefore, a compact yarn has a tenacity which is about 15 to 20 % above the tenacity of a regular ring-spun yarn. This is valid under the assumption that the yarns are produced with the same raw material.

Therefore, it is possible to reduce the twist as an alternative to increase the productivity of the ring spinning machine if the higher yarn strength is not required (Fig. 7).



*Fig. 7
Options to increase the
productivity by lowering the
twist for compact yarn
(Source: Rieter)*

2.9 Accuracy of yarn twist measurement

Every measuring system has its limitation with respect to accuracy of the results. This is also valid for twist testing. However, the accuracy of this system is very high.

The behaviour of measuring systems with respect to accuracy is frequently checked by the evaluation of inter-laboratory variations. The inter-laboratory variations CV_b for twist with the Zweigle system is around 1%.

Example

Testex round trial no 80, cotton 100 %, Ne 40, combed,

Sample size: 10 bobbins

Extraction of the Zweigle results; participants: 34 spinning mills

Mean $\bar{x}$: 986

Standard deviation s: 16.9

Interlaboratory variation: $CV_b = \frac{s}{\bar{x}} = \frac{17,7}{985} = 0,018 = 1,8\%$

Confidence interval: $Q_{95\%} = \frac{t \cdot s}{\sqrt{n}} = \frac{2,2 \cdot 17,7}{\sqrt{34}} = \frac{2,2 \cdot 38,9}{5,83} = 6,7$

The probability, therefore, is 95% that the mean of the twist lies within the limits 978 and 992 (1/m) if another sample of 10 bobbins is measured from the same lot.

3 Benchmarks

In order to compare the twist values with the world production, Uster Technologies offers benchmarks for twist testing.

Fig. 8 and Fig. 9 are recently developed benchmarks for twist. These figures are examples for cotton 100%, ring-spun yarn, carded, bobbins, for knitted fabrics.

Fig. 8 represents the USTER® STATISTICS for twist and Fig. 9 shows the USTER® STATISTICS for twist variation.

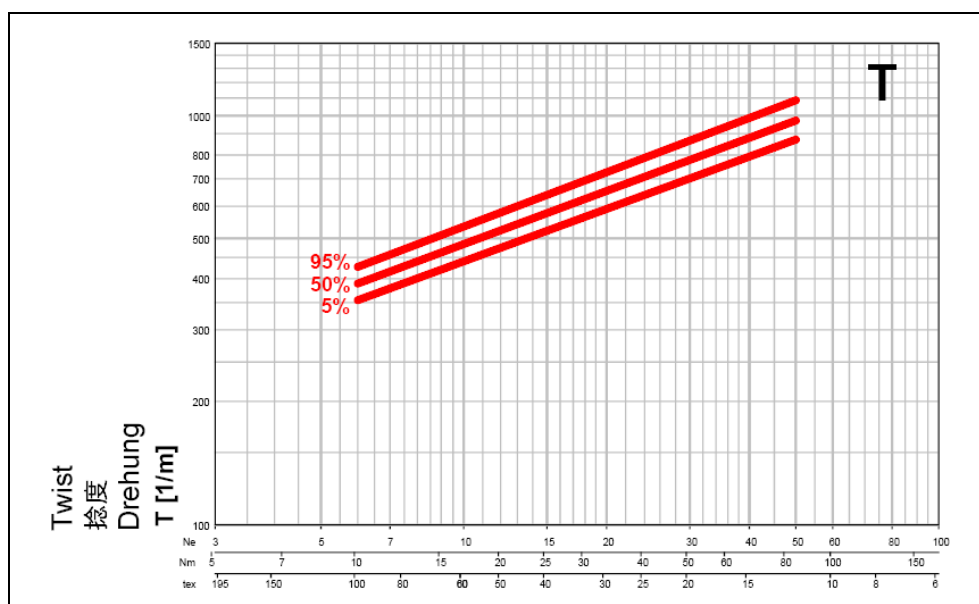


Fig. 8
Example, USTER®
STATISTICS for twist

Interpretation of Fig. 8: most of the measured values taken from the USTER® STATISTICS database were close to the 50%-line with some variations. 90% of all the values were between the 5% and 95%-line. The 95%-line does not mean that values on this line are inferior to values on the 5%-line. It simply means that the yarns with twist values on the 95%-line were produced with more twist and, therefore, with lower productivity.

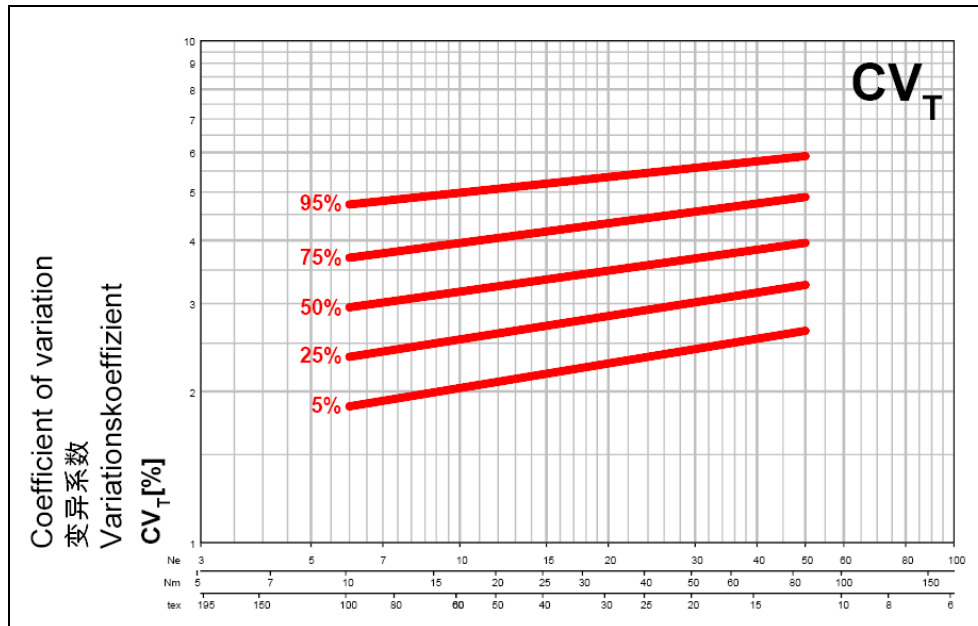


Fig. 9
Example, USTER®
STATISTICS for twist
Variation. Carded cotton.

Fig. 9 shows the variation of twist for the cotton yarn mentioned above. It is an evaluation of the values of the USTER® STATISTICS database.

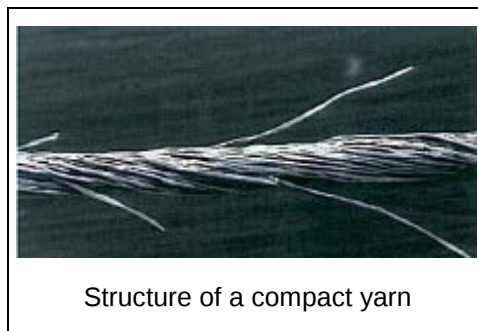
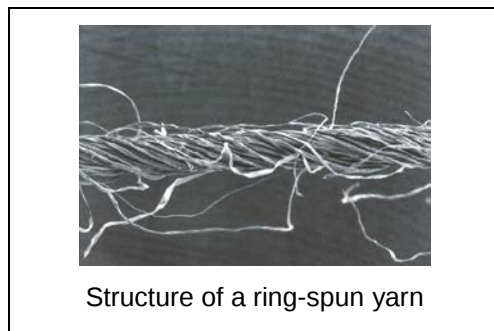
For a complete collection of benchmarks (USTER® STATISTICS for twist) see application report SE 633.

4 Yarn twist of alternative spinning systems

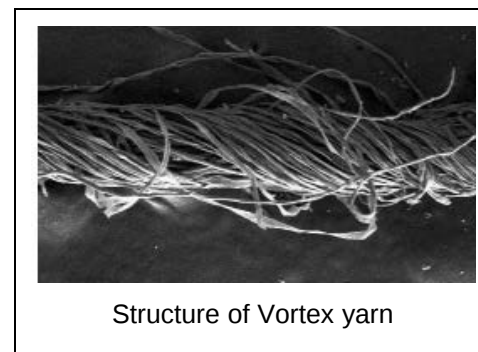
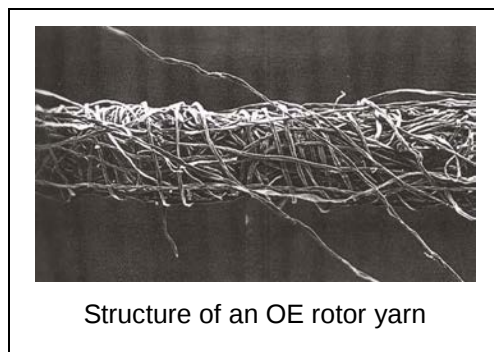
There are currently four spinning systems in the market:

- Conventional ring spinning system (Fig. 10)
- Compact spinning system (Fig. 10)
- OE rotor spinning system (Fig. 11)
- Vortex spinning system (Fig. 11)

The conventional ring spinning and the compact spinning system are both ring spinning systems where the embedded fibers in the yarn body have a preferred direction. The twist of these two yarns can easily be measured.



*Fig. 10
Structure of ring-spun yarn
and compact yarn*

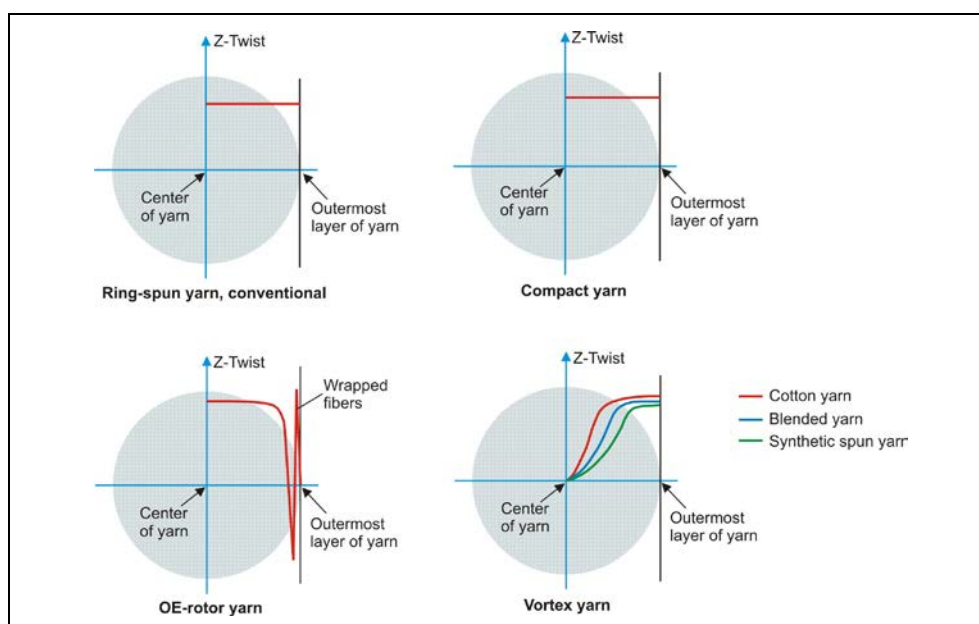


*Fig. 11
Structure of OE rotor yarn
and Vortex yarn. The inner
layers have less twist.*

Fig. 12 shows the twist characteristics of the 4 spinning systems. Ring-spun yarn and compact yarn have approximately the same preferred fiber directions from the center of the yarn to the outermost layer.

OE rotor yarns have a preferred fiber direction in the center of the yarn, but the outermost layers are wrapped fibers (see also Fig. 11).

Vortex yarns have untwisted fibers in the yarn center and twisted fibers at the yarn surface (Fig. 11, Fig. 12).



*Fig. 12
Twist characteristics of
various spinning systems
(Source: Muratec)*

For the spinning systems OE rotor and Vortex there exist no internationally accepted rules for the measurement of the yarn twist. Therefore, spinning mills mostly measure the twist of these two yarns according to internal regulations or by means of other parameters (strength, elongation).

OE rotor machine manufacturers provide recommendations for the twist setting of OE rotor yarns on the machines. Fig. 13 shows the recommended twist and twist range for various fibers which are processed on an OE rotor spinning machine. Fig. 13 demonstrates that the twist setting must be higher for short or very short fibers.

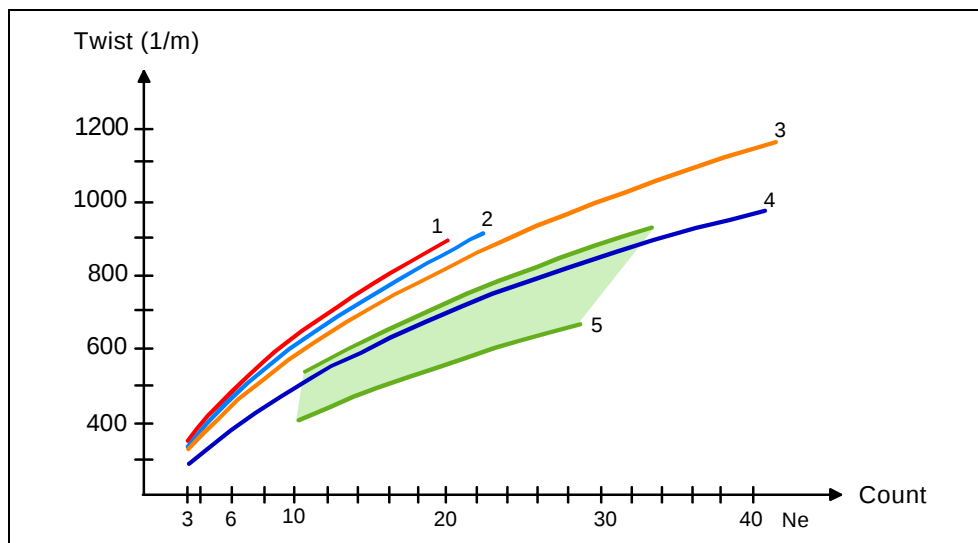


Fig. 13
Twist for OE rotor yarn
(Source: Rieter)

Explanation of the figures:

- 1 = Comber noil ($\alpha_e = 5.1$)
- 2 = Cotton waste ($\alpha_e = 5.0$)
- 3 = Cotton 1" – 1 1/8" ($\alpha_e = 4.7$)
- 4 = Synthetic fibers 38 mm ($\alpha_e = 3$)
- 5 = Twist for hosiery yarns, raw mat. according to 3, 4 ($\alpha_e = 3.2$ to 4.1)

5 Twist measuring methods

With the Zweigle twist measuring system five different twist measuring methods can be selected. The most common method is the simple untwist-retwist method (Fig. 14).

The Zweigle measuring system can also be applied for the measurement of filament yarn twist.

For other twist measuring methods please consult the Application Manual of the USTER® ZWEIGLE TWIST TESTER 5.

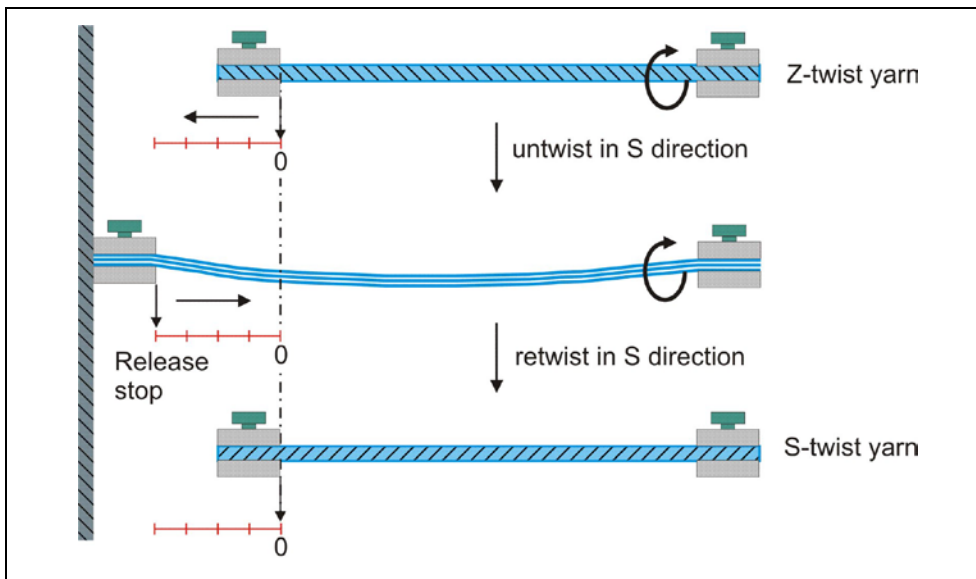


Fig. 14
Twist measuring principle

In a first step the yarn is untwisted until the yarn reached the status where all the fibers have the direction of the yarn axis. This is the twist position where the yarn reaches the largest extension. In a second step the yarn is twisted in the same direction again until the yarn reaches the original length (change from Z-direction to S direction or vice versa).

6 Measuring standard for twist

The most important measuring standard is ASTM 1423.

7 Conclusion

The twist is an important quality parameter of yarns. The twist determines various other characteristics such as the hairiness, the density, the strength, the elongation, the hand, the productivity, etc.

Uster Technologies has developed benchmarks for yarn twist. One example for carded cotton yarns is shown in Fig. 8 and Fig. 9.

This paper serves as an introduction into twist measurement.

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